Sci. J. Fac. Sci. Menoufia Univ. Vol . IX (1996) : 153 - 170

THE MINERALOGY AND EVALUATION OF QAHMAH BEACH PLACER DEPOSIT, SOUTH -WESTERN, SAUDI ARABIA

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ABSTRACT

Qahmah coastal area lies on the Red Sea coast between Latitude 17° 52` - 18° 06` North and Longitude 41° 36` - 41° 43` 30`` East . The flat coastal plain extends inland 2.10 - 5.2 kms from the beach giving a large potential area for a beach placer deposit . The principal minerals recorded are magnetite and ilmenite with titanium to iron ratio 1: 5 .

The present study deals with the mineralogy of the deposit which is believed to help in the identification of the placers and sedimentational environment. The ore microscopy revealed that magnetite is the main opaque with ilmenite, hematite, and very rare sponge-like native iron. Sphene and amorphous Fe-Ti oxides were formed by alteration and replacement.

The non-opaque heavy minerals recognized are represented mainly by zircon, biotite, hornblende, pyroxene, epidote rutile and garnet .

The Placer is statistically evaluated through the quantitative and chemical analyses of fifty samples from five traverses.

About 537, 345 tons of strongly magnetic concentrate with average percentages 54.66 Fe, 10.41 Ti, 0.63 Mn, 0.82 Cr., 0.16 S, and 9.36 SiO2 were determined.

INTRODUCTION

The first discovery of magnetic deposit at Qahmah (Fig. 1) was recorded in the U.S. Navy Hydrographic chart of the Red Sea published in 1938 during installation of storage bins and ship loading facilities.

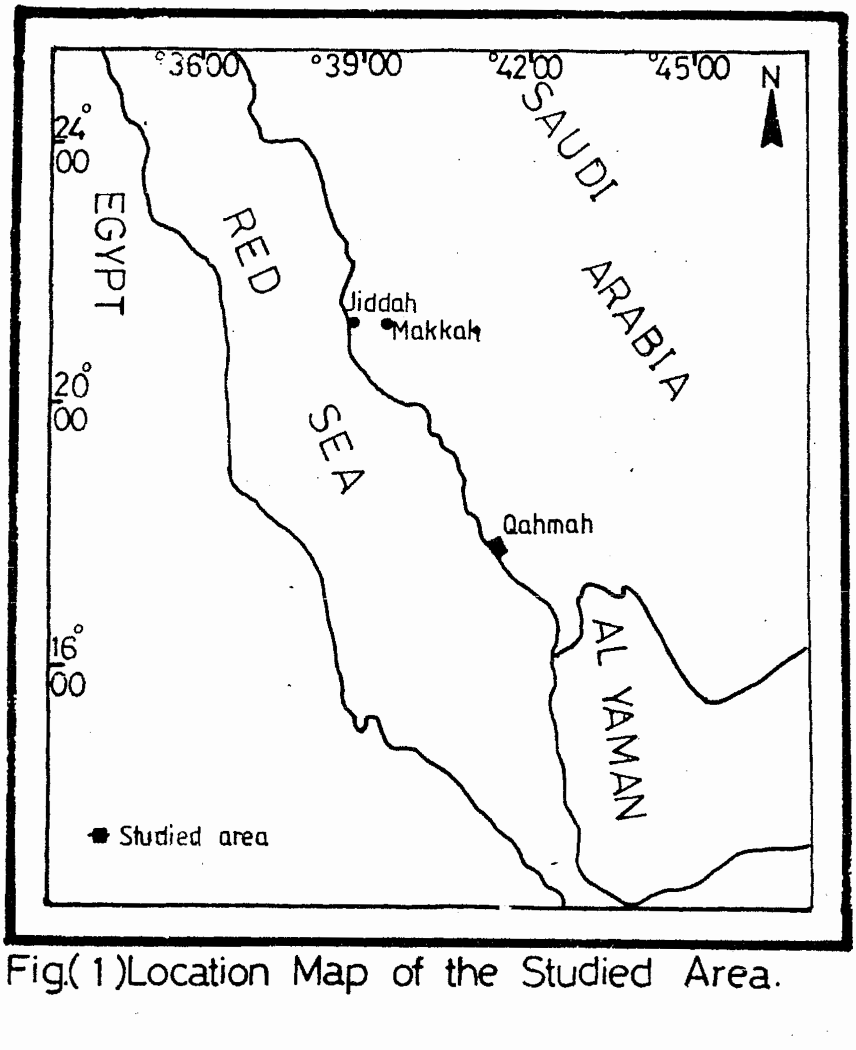

Fig.(1)Location Map of the Studied Area.

Schaffner (1958) , considered the samples taken as preliminary indication only, because no test hole drilled in the area reached the bedrock . The area was roughly estimated to contain 182,000 tons magnetite. Bhutta (1962) followed mainly the previous Schaffner`s report. He divided the area into two sectors and roughly calculated the reserves of the strongly magnetic concentrate, on the base of 90 lbs. per cubic feet, to be 271, 625 tons.

The main goal of the present study is to identify, the economic minerals particularly opaques in the deposit and shed light on the importance of Al Qahama placers.

Sampling:

In the present study, the auger-sampling was made along the following traverses: (1) A continuous length of 27000` of beach was sampled by 25 test holes at 1000` intervals 55` to 150` inland from the surf line. The beach being limited by the sand dunes, to the east, where the magnetic material is well sorted by the combined action of waves and wind, (2) Westward and at right angle to the beach-line at richest location, as indicated by schaffner, another line of 5 holes drilled inland at 200` intervals, (3) Two test holes were drilled in Wadi Hamidah at 200` intervals, (4) Five samples were taken from the high dunes in the south area at 300` intervals, and (5) Three samples from the low dunes at 400` intervals were taken from the central area.

Bed rock of reefal limestone, calcareous sandstone and a reef-conglomerate was reached at depths between 1-50 ft (Bhutta, 1962).

Methods of study:

Samples were washed in tap water to remove salt and the fine clay material. The washed samples were dried and passed through a

10 mesh sieve to remove pebbles, bits of wood and other foreign material. 500 gm samples (from the minus 10 mesh portions) were separated into heavy and light mineral fractions by means of bromoform of specific gravity 2.8. The heavy fraction was further separated using an alnico horseshoe magnet to separate the magnetic fractions. The weakly magnetic portion was removed from the heavy mineral fractions and samples for chemical analysis of magnetic, weakly magnetic and non-magnetic material were prepared and analysed for Fe, Ti, Mn, Cr, Ni, V, P, S, SiO_2 using the X-ray fluorescence technique .

Two parts from both heavy and light mineral fractions were examined under the binocular microscope and with ultraviolet light. The only fluorescent mineral was zircon which was a bright, golden yellow in ultraviolet light. Shell-fragments showed a slight fluorescence as a dull orange yellow .

Canada balsam mounts of the heavy mineral fractions of size 0.25-0.063mm were made for mineral determinations under the petrographic and ore microscopes.

Field distribution of magnetic minerals

The table given below shows the tentatively the quantitative distribution of magnetic material in the placer deposit of Qahmah.

Samples	averaged	% Strongly magnetic	% Weakly magnetic	% Non-magnetic
25	Test holes along beach (1000` interval)	12.65	1.68	36.44
5	Test holes (200` interva)	7.37	1.54	35.85
2	Test holes in Wadi Hamidah (200` interval)	6.00	1.25	24.05
10	Samples from high dunes in south area parallel to the beach 9300` interval).	6.12	1.55	22.87
8	Samples from low dunes in central area parallel to the beach (400` interval).	12.42	2.10	10.89

The beach samples show that the magnetic material forms definite layers, 3-5 feet thick and 55-150 ft wide, gently inclined seaward. The heavy minerals have been concentrated by surf action along the beach. From 150-450 feet inland the magnetic black material is poorly sorted. The weakly magnetic zone stretches inland for not more than 300 feet. The magnetic ratio generally decreases landward and increases to bedrock.

The black magnetic minerals have been increased by aeolian processes in the active dunes which lie in an area of about 1000` wide paralleling the surf line.

Mineralogy

The light fraction of grain size 0.25 to 0.063 mm is composed mainly of quartz with subordinate amount of carbonates (calcite) and feldspars (orthoclase , microcline and plagioclase) . The non-opaque heavy minerals are represented mainly by: zircon, garnet, epidote, rutile, biotite, pyroxene and hornblende. It is believed that they were derived from the igneous-metamorphic rocks in close vicinity to the east of the area .

On the average the heavy fraction contains 67.6% opaque minerals . Ore microscopic studies show that the opaque minerals are represented mainly by magnetite, ilmenite with lesser amounts of hematite, and rare amount of native iron. No sulphides were observed . The terminology adopted for describing the various intergrowths of Fe -Ti minerals is that given by Ramdöhr (1980).

Magnetite

Magnetite is the predominant mineral among the total opaques . Homogeneous single phase magnetite free from any exsolution is the main type (Plate, I, Fig. 2) . About 35.7 to 50.8% of the magnetite grains were transformed to martite and iron oxide, while 13.5% are fresh. It is clearly indicated that magnetite is less stable than ilmenite being affected by weathering and the transporting media .

Ilmenite

Ilmenite is the second predominant mineral among the opaques, it occurs either as a single phase free of any exsolution (Plate I, Fig. 3) or as exsolution replacing magnetite in many cases. On the base of colour variation, ilmenite ranges from normal ilmenite to Fe_2O_3-rich ilmenite presents as subrounded to rounded grains.

Native iron

Native iron is present as sponge-like grains (Plate I, Fig. 4). Sometimes native iron grains commonly show juxtaposition of thin plates of ilmenite on or near iron grain peripheries forming rims (Plate I, Fig. 5).

Alteration product of magnetite and ilmenite

A. Martitization:

i. Pseudohematite - magnetite intergrowth or Hematite relics in magnetite pseudomorphs :

The grains are almost composed of hematite pseudomorphs after magnetite which is still to be found as such in the grey areas (Plate I, Fig. 6). The coarse hematite lamellae in these grains are possibly the result of formation at deep burial whereas the small lamellae often containing ting holes correspond to the normal perhaps even climatically induced martitization (Plate I, Fig. 7) .

Many particles showed the grains of hematite (martite) pseudomorphs after magnetite, whereby relics of magnetite still remain and in some cases strong zonal pseudomorphs of magnetite after hematite lenses (Plate II, Figs. 8 & 9), with relics of hematite are still recognizable .

ii. Oriented network and lattices :

Ilmenite may show distinct rectangular lattice of twinning lamellae of two oriented intergrowths . A few very thin oriented plates of magnetite (martite) are found diagonal to this structure . The ilmenite, therefore, must have had an excess of iron unmixed as magnetite. Here we have a fine network of ilmenite in magnetite grains parallel to the (111) plane (Plate II, Fig. 10). This network was developed by the decay of ilmenite plates.

B. Transformation, zones of ilmenite surrounding magnetite :

Grains of magnetite are found with a broad rim of ilmenite. The distinctly separated outer zone of ilmenite originated later out of the magnetite as a reaction rim (Plate II, Fig. 11) . The magnetite shows no exsolution of ilmenite .

C. Sphene-Ilmenite Intergrowths:

Sphene-ilmenite intergrowth occurs as a result of replacing ilmenite by Sphene (Plate II, Fig. 12). Sphene replaced ilmenite at cleavage planes, cracks and grain boundaries. Sphene rims, shreds and island-like relics of ilmenite are also observed due to the processes of replacement.

D. Replacement of calcite by magnetite:

Grains of calcite replaced by magnetite are occasionally observed in the deposit. In zoned grains the actual host mineral calcite is preserved in the actual guest mineral, magnetite. The zonal growth, typical for contact metasomatic magnetite, is clearly recognizable as shown in (Plate II, Fig. 13).

Chemical Determinations

Chemical analyses after magnetic fractionation were carried out in the laboratories of the Geological Survey of Egypt and mining authority by means of X-ray fluorescence type PW1410. Data of the average chemical analyses for the elements Fe, Ti, Mn, Cr, Ni, P and S as well as SiO_2 are given in the following table .

Results of chemical analyses of the magnetic and non-magnetic fractions

Sample	Strongly Magnetic					Averaged	Weakly Magnetic					Averaged	Non Magnetic					Averaged
Average Elements	Average Along Beach (1000' interval)	Average inland (200' interval)	Average In Wadi Hamidah (200' interval)	Average High Dunes (300' interval)	Average Low Dunes (400' interval)	chemical analysis of the strongly Magnetic samples	Average Along Beach (1000' interval)	Average Inland (200' interval)	Average In Wadi Hamidah (200' interval)	Average High Dunes (300' interval)	Average Low Dunes (400' interval)	chemical analysis of the weakly Magnetic samples	Average Along Beach (1000' interval)	Average Inland (200' interval)	Average In Wadi Hamidah (200' interval)	Average High Dunes (300' interval)	Average Low Dunes (400' interval)	chemical analysis of the non Magnetic samples
Fe	58.6	56.45	50.10	50.65	57.54	54.66	32.72	29.99	24.35	30.19	40.91	31.63	19.07	18.83	13.92	13.42	8.43	14.73
Ti	13.71	9.05	7.84	7.93	13.51	10.41	10.31	9.52	7.59	9.59	13.01	10.00	8.65	8.27	6.40	6.08	4.19	6.72
Mn	0.81	0.55	0.49	0.50	0.80	0.63	0.49	0.45	0.38	0.46	0.60	0.48	0.45	0.44	0.32	0.31	0.19	0.34
Cr	1.08	0.71	0.61	0.63	1.07	0.82	0.34	0.30	0.26	0.30	0.37	0.31	0.21	0.20	0.14	0.13	0.07	0.15
Ni	T	R	A	C	E	Trace	T	R	A	C	E	Trace	NO	NO	NO	NO	NO	NO
V	T	R	A	C	E	Trace	T	R	A	C	E	Trace	NO	NO	NO	NO	NO	NO
P	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
S	0.21	0.14	0.12	0.13	0.20	0.16	0.06	0.05	0.04	0.05	0.07	0.05	T	R	A	C	E	Trace
SiO_2	12.40	8.11	6.99	7.09	12.21	9.36	31.00	28.54	23.44	28.71	38.38	30.01	46.72	46.14	34.45	33.28	21.4	36.40

It is obvious that the elements Fe, Ti, Mn and Cr or S decrease in contents as magnetic susceptibility decreases. Ni and V are detected as traces in both the strongly magnetic and weakly magnetic, but they are absent in the non-magnetic. P is absent in all samples analysed. SiO_2 decreases proportionally with the increases of the magnetic character.

Tentative Evaluation of the Deposit :

The reserves of the strongly magnetic concentrate was statistically calculated by the present author based on the following average data :

Average Lbs./cubic foot	Concentration %	Width	Thickness (ft)	Lateral spreading (ft)
Along Beach 95	13.22	75	4	27.000
Inland				
a) 400\` 70	6.71	400	5	27.00
b) 61	3.32	600	3	200
In Wadi Hamidah				
83	7.55	400	5	200
In High dunes 90	5.62	1000	3	6750
In low dunes 98	15.60	1000	5	6750

$$\text{The reserve} = \text{lateral spreading x width x thickness x} \frac{\text{Lbs} / f^3}{2000} \text{x concentration \%}$$

1. Along the beach :

$$\text{The reserve} \frac{27000 \times 75 \times 4 \times 95 \times 13.22}{2000 \times 100} = 50.864 \text{ tons.}$$

2. Inland :

a- The reserve in the first 400\` $= \frac{27000 \times 400 \times 5 \times 70 \times 6.71}{2000 \times 100}$ 126,819 tons.

b- The reserve in the next 600\` $= \frac{27000 \times 3 \times 61 \times 3.32}{2000 \times 100}$ 49,212 tons.

3. In Wadi Hamidah

The reserve $= \frac{27000 \times 400 \times 5 \times 83 \times 7.55}{2000 \times 100}$ 1,253 tons.

4. In high dunes :

The reserve $= \frac{6750 \times 1000 \times 3 \times 90 \times 5.62}{2000 \times 100}$ 51,212 tons.

5. In low dunes :

The reserve $= \frac{6750 \times 1000 \times 5 \times 98 \times 15.6}{2000 \times 100}$ 257.985 tons.

Thus the estimated total tonnage of the strongly magnetic minerals in the deposit reaches 537.345 tons.

DISCSSION AND CONCLUSION

The present study has revealed that the heavy minerals identified in placer of Qahmah are represented by an assemblage rich in opaques and non opaques stable and ultrastable minerals . The ore microscopic investigation revealed that magnetite is the main opaque constituent, in addition to ilmenite, hematite, and minor sponge-like native iron. Sphene and amorphous iron-titanium oxides are the alteration and replacement products of ilmenite.

Total reserve of the strongly magnetic concentrate in Qahmah deposit is estimated to be about 537.345 tons.

Several studies on beach placer deposits have been carried out in different countries, e.g. Egyptian black sands after Rittman &

Nakhla (1958) and Kamel , et al., (1973) and in the Nile Quaternary sediments in the northern upper Egypt by Kamel, et al. (1994), Indonesian magnetite of U. N. Report (1955) , Cyprus Beach deposits of Varnavas (1986) and mineral placers on Southern Oregon Continental Shelf of Klum (1988) .

In comparison with other yielding countries, Qahmah deposit is relatively smaller in size and less in grade and amount.

The Egyptian black sands contain 50.67% ilmenite, 15-16% magnetite, 7.29% zircon, 1.83% garnet, 1.06% monazite and 1.04% rutile; the remainder is of quartz, hornblende and calcite gangue. About 7.5% of the beach sand constituents are minerals of economic value (Rittman and Nakhla, 1958).

The total reserves of economic minerals (magnetite, ilmenite, hematite, rutile, monazite and garnet) in the black sands at Abu Khashaba area east of Rosetta reaches about 25,445,000 tons with 204,000 tons of ilmenite (Kamel, et al. 1973).

The iron sands of New Zealand 496 million tons of titano-magnetite concentrate assaying 61% Fe, 9.05% TiO2, 2.49% Al2O3, 0.41% V2O3, 2.95% SiO_2, and 0.21% P (U. N.Report,1955).

Indonesian magnetite sands was estimated to contain 7 million tons of magnetic material assaying 50% Fe, 16% TiO_2, 0.01% P, 0.06% S and 5-20% SiO2 (U.N. Report, 1955).

Acknowledgments

The author would like to express his deep thanks to the Saudi Arabian Ministry of Petroleum and Mineral Resources, Geological Survey (SGS) for their help and cooperation.

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Plate I

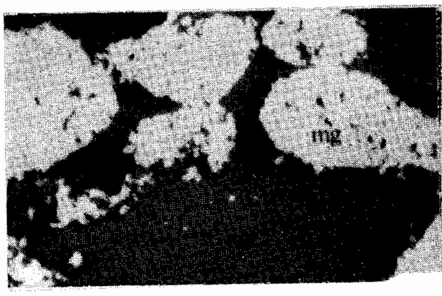


Fig. (2)

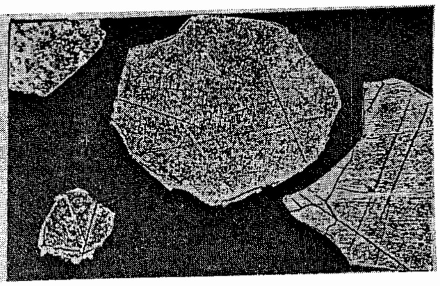
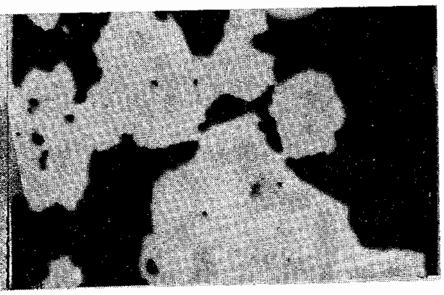


Fig. (3)

Fig. (4)



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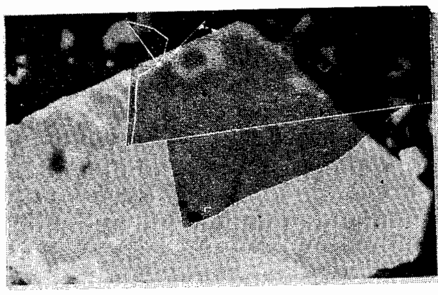

Fig. (6)

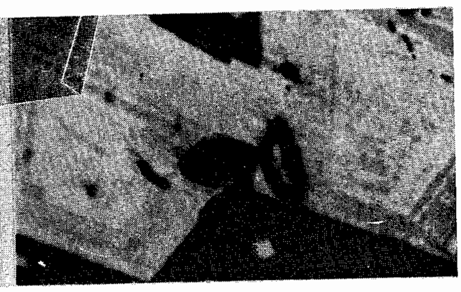

Fig. (7)

EXPLANATION OF PLATES

Plate I :

Fig. 2 : Fresh homogeneous magnetite grains with smooth rounded corners. R.L. X220.

Fig. 3 : Ilmenite grains show sporadic twinning lanellaea indicating that they were subjected to a mechanical stress after their crystallization. R.L. X400.

Fig. 4 : Sponge-like native iron grains. R.L. X220.

Fig. 5 : Native iron grains shows jauxtaposition of thin plates of ilmenite on or near their peripheries. R.L. X220.

Fig. 6 : Grains of hematite pseudomorphs after magnetite which is still to be found in the grey areas. R.L. X900.

Fig. 7 : Magnetite grains with coarse and small hematitic zones. R.L. X500.

Plate II

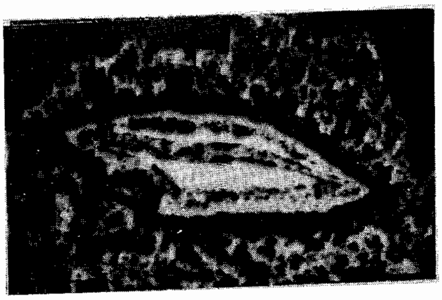

Fig. (8)

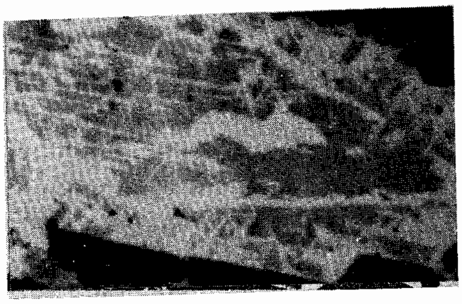

Fig. (9)

Fig. (10)

Fig. (11)

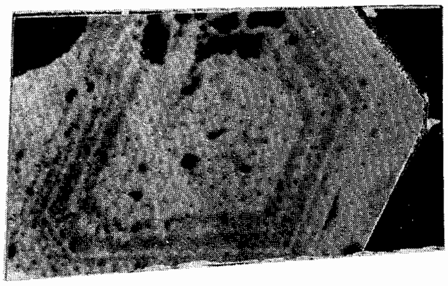

Fig. (12)

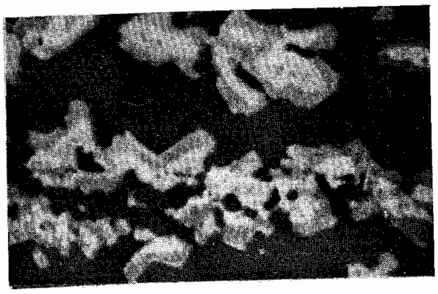

Fig. (13)

Plate II :

Fig. 8 : Strong zonal pseudomorphs of magnetite after hematite lenses, whereby relics of hematite are recognizable, oil mmersion X350.

Fig. 9 : Enlarged one of the hematite lenses of Fig. 8, oil immersion X900.

Fig. 10 : Two oriented intergrowths. A fine network of ilmenite in magnetite grains parallel to (111) plane. R.L. X220.

Fig. 11 : Grains of magnetite with a broad rim of ilmenite, oil immersion X220.

Fig. 12 : Ilmenite grains (white) intensely replaced by sphene rims (grey), oil immersion X220.

Fig. 13 : Zonal intergrowths with replacement. Magnetite is dominates over that of calcite. R.L. X900.

الدراسة المعدنية والتقييم الاقتصادى لرواسب الرواقد الشاطئية بمنطقة قحمة بجنوب غرب المملكة العربية السعودية

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تقع رواسب الرواقد فى المنطقة الشاطئية لقحمة المطلة على شاطئ البحر الأحمر والمحصورة بين خطى عرض ٥٢َ ١٧° و ٠٦َ ١٨° شمالا وبين خطى طول ٣٦َ ٤١° و ٣٠ً ٤٣َ ٤١° شرقا. ويمتد السهل الساحلى إلى الداخل من الشاطئ حوالى ١ر٢ – ٢ر٥ كم مكونة مساحة شاطئية كبيرة محتوية على رواسب الرواقد . ولقد ثبت من الدراسة أن المعادن الأساسية المكونة لتلك الرواسب هى المجنتيت والألمنتيت بنسبة ١ : ٥ تيتانيوم إلى حديد .

ويهتم العمل الحالى بالدراسة المعدنية التى يعتقد إنها تساعد فى التعرف على البيئة الترسيبية لتلك الرواقد . ولقد أظهرت الدراسة المجهرية للخام أن المعادن المعتمة تتكون من المجنتيت مع الألمنيت ، الهيماتيت ، وكميات ضئيلة جدا من خام الحديد الإسفنجى . أما الإسفين والاكاسيد الغير متبلورة لـ Fe - Ti فأنها تكونت نتيجة لعوامل التحول والإحلال .

أما المعادن الثقيلة الغير معتمة فهى ممثلة أساسا بـ الزركون ، بيوتيت ، هورنبلند ، بيروكسين ، روتيل أبيدوت وجارنت .

ولقد قيمت كميات الرواقد كميا ، كما تم تحليل خمسون عينة من خمسة خطوط ممثلة للمنطقة بحوالى ٣٤٥ و ٥٣٧ طن من الرواسب عالية التمغنط بمتوسط تركيز قدرة ٦٦ر٥٤ Fe ، ٤١ر١٠ Ti ، ٦٣ر٥ Mn ، ٨٢ر٠ Cr ، ١٦ر٠ S و ٣٦ر٩ SiO_2 .